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DESCRIPTION

OXYGEN CONCENTRATING APPARATUS

TECHNICAL FIELD

The present invention relates to an oxygen concentrating apparatus including a cooling device for a compressor which supplies compressed air to a plurality of adsorption columns filled with an adsorbent such as zeolite.

BACKGROUND ART

Oxygen inhalation therapy has been employed as a most effective method of treatment for respiratory system diseases such as asthma, pulmonary emphysema or chronic bronchitis. In oxygen inhalation therapy, an oxygen concentrated gas is supplied to the patient. For this purpose, package-type oxygen concentrating apparatuses have been developed for use in the home. The package-type oxygen concentrating apparatus includes an oxygen concentrating unit for producing oxygen gas by separating nitrogen gas from the air, a compressor for supplying compressed air to the oxygen concentrating unit and a case for accommodating the oxygen concentrating unit and the compressor in order to insulate the noise. Japanese Unexamined Patent Publications (Kokai) No. 62-140619 and No. 63-218502 disclose examples of such apparatuses.

DISCLOSURE OF THE INVENTION

Recently, some oxygen concentrating apparatus further include a compressor housing, disposed in the case, for accommodating the compressor in order to minimize the noise emission from the apparatus. However, the compressor housing prevents the compressor, disposed therein, from being cooled.

Therefore, the objective of the invention is to provide an oxygen concentrating apparatus improved to

efficiently cool the compressor disposed in the compressor housing while an increase in the weight of the apparatus is minimized.

According to the invention, there is provided an oxygen concentrating apparatus which comprises an oxygen concentrating unit, including an adsorption column filed with an adsorbent material which selectively adsorbs nitrogen gas more than oxygen gas, a compressor for supplying compressed air to the oxygen concentrating unit, a compressor housing for accommodating the compressor, the compressor housing including a plurality of air inlet ports for introducing the air into the compressor housing and an air outlet opening for discharging the air from the compressor housing, a cooling fan mounted on the compressor housing at the air outlet opening for drawing the air from the compressor housing and the air inlet ports being disposed adjacent the side wall of the compressor to direct the air flow induced by the cooling fan perpendicularly to the side wall of the compressor. The capacity of the cooling fan and the diameter of the air inlet ports are selected to ensure that a velocity of the air flow through the air inlet ports is equal to or lower than 15m/sec.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagrammatic section of an oxygen concentrating apparatus according to an embodiment of the present invention.

Figure 2 is a diagrammatic section of a compressor used in the oxygen concentrating apparatus shown in Figure 1.

Figure 3 is a block diagram of an experimental apparatus used to determine the effect of the present invention.

Figure 4 is a graph showing experimental results obtained by using the apparatus of Figure 3.

Figure 5 is a graph showing other experimental

results obtained by using the apparatus of Figure 3.

Figure 6 is a graph showing other experimental results obtained by using the apparatus of Figure 3.

Figure 7 is a graph showing other experimental results obtained by using the apparatus of Figure 3.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to Figures 1 and 2, a preferred embodiment of the present invention will be described below.

An oxygen concentrating apparatus 10 according to the embodiment of the invention includes an oxygen concentrating unit 12, a compressor unit 14 for supplying the compressed air to the oxygen concentrating unit 12, a tank 16 for containing the oxygen concentrated gas from the oxygen concentrating unit 12, a battery as an electric power source 18 for the oxygen concentrating unit 12 and the compressor unit 14, electric circuit boards 20 and 22 for controlling the oxygen concentrating unit 12 and the compressor unit 14, and a case 24 accommodating all of the above elements 12-22. The oxygen concentrating apparatus 10 further includes a plurality of conduits or pipes (not shown) for fluidly connecting the oxygen concentrating unit 12, the compressor unit 14 and the tank 16. The case 24 includes an air inlet opening 24a, through which the air is introduced into the case 24, and a gas outlet opening 24b through which the nitrogen gas, separated from the air by the oxygen concentrating unit 12, is exhausted.

Preferably, the oxygen concentrating unit 12 may comprise a pressure swing type gas separator. In this particular embodiment, the oxygen concentrating unit 12 includes a plurality of adsorption columns 12a filled with an adsorbent such as zeolite which selectively adsorbs nitrogen gas more than oxygen gas. The oxygen concentrating unit 12 further includes switching mechanisms 12b and 12c for sequentially selectively

switching the adsorption columns to which the air is supplied from the compressor unit 14, and the adsorption columns from which the absorbed nitrogen is released, for regeneration of the adsorbent so that the respective adsorption columns repeatedly absorb nitrogen gas and release the absorbed nitrogen gas according to an absorption-regeneration cycle.

With reference to Figure 2, the compressor unit 14 includes a compressor 26, a compressor housing 28, made of a suitable material, for example, a synthetic resin, such as NBR (acrylonitrile-butadiene rubber), to accommodate the compressor 26 and to provide noise insulation, and a cooling fan 30. The housing 28 has a foamed polyurethane linear attached to the inner surface thereof as a noise insulating material. The compressor 26 may comprise any type of compressor, such as a reciprocating compressor and a rotary compressor. In the embodiment of Figure 2, the compressor 26 is a reciprocating compressor and is, for example, a Horizon Model 2250 pressure/vacuum pump, available from Rietschle Thomas, 7222-T Parkway Dr., Hanover, MD. The compressor has cylinders 26a within which pistons (not shown) are slidably disposed, cylinder heads 26b attached to the ends of the cylinders 26a and a diving motor 26c. The output shaft of the driving motor 26c is connected to a crank shaft (not shown) to which the pistons are connected through connection rods so that the rotation of the driving motor 26c is transformed to the reciprocation of the pistons.

The compressor housing 28 preferably has a configuration similar to the exterior configuration of the compressor 26 to efficiently pass the air along the surface of the compressor 26. The compressor housing 28 includes a plurality of air inlet ports 28a, an air outlet opening 28b and at least side walls facing the cylindrical side walls of the cylinders 26a and defining the inlet ports 28a. A cooling fan 30 is mounted on the

compressor housing 28 at the air outlet opening 28b. In this particular embodiment, the housing 28 includes twenty-eight (28) air inlet port 28a having diameter of 6mm. The air inlet ports 28a are disposed around the cylinders 26a to direct the air flow, induced by the cooling fan 30, through the air inlet ports 28a perpendicularly to the outer surfaces of the cylinders 26a adjacent the ends thereof where the temperature of the air in the cylinders 26a is increased by the compression of the air and the friction between the pistons and the inner surfaces of the cylinders 26a. This configuration allows the air flow to impinge against the outer surfaces of the cylinders 26a and to increase the cooling effect of the air flows. The air introduced into the compressor housing 28 through the air inlet ports 28a is exhausted into the case 24 through the air outlet opening 28b.

With reference to Figures 3-7, the effect of the present invention will be described below.

Figures 4-7 are graphs showing experimental results obtained by using the apparatus of Figure 3. In Figure 3, an experimental apparatus 100 has a dummy compressor unit 110 and a vacuum pump 120 fluidly connected to the dummy compressor unit 110 through a conduit 122. The dummy compressor unit 110 includes a heater unit 112, having a cylindrical exterior configuration and thermal output of 75W, for demonstrating the heat generation in the compressor 26, a hollow cylindrical housing for accommodating the heater unit 112 and a pressure gauge 118 for detecting the pressure in the housing. A plurality of air nozzles 116, in particular twenty-eight (28) nozzles 116, for directing cooling air perpendicularly to the outer surface of the heater unit 112, are disposed in the side wall of the housing 114.

In the conduit 112 between the dummy heater unit 110 and the vacuum pump 120, a valve 124 and a flowmeter 126, for controlling and measuring the flow rate of the air

through the conduit 122, are provided. The experimental apparatus 100 further includes temperature sensors (not shown) for detecting the temperature difference between the outer surface of the heater unit 112 and the room temperature. When the vacuum pump 120 draws the air in the housing 114, the air flow through the nozzles 116 impinges perpendicularly on the outer surface of the heater unit 112 to cool it.

Figure 4 shows the changes in the temperature of the outer surface of the heater unit 112 and the pressure loss through the nozzles 116 relative to the changes in the air flow rate. In this connection, please note that temperature of the outer surface of the heater unit 112 is indicated by the temperature difference ΔT between the outer surface of the heater unit 112 and the room temperature. As shown in Figure 4, the larger the air flow, the more the heater unit 112 is cooled, and the greater the pressure loss through the nozzles 116.

Figure 5 shows the changes in the temperature of the outer surface of the heater unit 112 and the pressure loss through the nozzles 116 relative to the diameter of the nozzles 116. The detailed experimental data in relation to the graph of Figure 5 are shown in Table 1 below.

TABLE 1

Dn (mm)	F (litter/min)	Ta (°C)	Ts (°C)	ΔT (°C)	ΔP (mmH_2O)	V (m/sec)	Re
2	290	21.7	44.9	23.3	207.1	55.0	6108
4	300	22.4	50.3	27.9	13.8	14.2	3159
6	397	22.0	60.0	38.0	1.0	3.5	1564

where

Dn: diameter of the nozzles

F: Air flow rate through the nozzles

Tr: room temperature

Ts: temperature of the outer surface of the heater unit 112

ΔT: Ts-Tr

ΔP: pressure loss through the nozzles

V: flow velocity of the air through the nozzles

Re: Reynolds number

As shown in Figure 5 and Table 1, when the flow velocity of the air is larger than 15m/sec, the pressure loss through the nozzles 116 rapidly and extremely increases. Therefore, according to the invention, diameter of the air inlet ports 28a and the flow rate of the cooling air therethrough are selected so that the flow velocity of the air flow through the air inlet ports 28a is lower than 15m/sec. If the air inlet ports 28a comprise different size ports, the diameter is estimated by the average of the size of each of the ports.

The compressor 26 is cooled by the air induced by the cooling fan 30. The cooling air flow is selected so that the temperature difference ΔT between the temperature Ts of the outer surfaces of the cylinders 26a of the compressor 26 and the room temperature Tr is kept lower than 30°C. As is well known in the art, the higher the power of the compressor, the larger the required flow rate of the cooling air.

Figure 6 shows that there are linear relations between the changes in the power of the compressor and the changes in the flow rate of the cooling air required to maintain the temperature difference ΔT lower than a predetermined value. Two particular cases are shown in Figure 6, one being a case of a temperature difference ΔT lower than 30°C, indicated by line-and-square mark, and the other being a case of a temperature difference ΔT lower than 20°C, indicated by line-and-triangle mark.

Figure 7 shows that there are linear relations between the changes in the power of the compressor and the changes in the flow velocity of the cooling air through the nozzles 116 required to maintain the temperature difference ΔT lower than a predetermined value. Two particular cases are shown in Figure 7, one

being a case of a temperature difference ΔT lower than 30°C, indicated by line-and-square mark, and the other being a case of a temperature difference ΔT lower than 20°C, indicated by line-and-triangle mark.

With reference to Figure 7, the cooling air at 15m/sec maintains the temperature difference ΔT at 30°C, with a compressor of 280W, and at 20°C, with a compressor of 140W, and therefore, can sufficiently cool a compressor which is commonly used for an oxygen concentrating apparatus. These experimental results provide parameters of 0.05m/sec W (ΔT=30°C) and 0.1m/sec W (ΔT=20°C), the flow velocity of the cooling air relative to the power of the compressor.

As described above, the pressure loss becomes excessively high when the velocity of air flow through the nozzles 116 is higher than 15m/sec. On the other hand, sufficient cooling of the compressor allows it to operate for long time. Further, in order to provide a large amount of cooling air, a large cooling fan is required, which will result in increase in the volume, weight, noise and power consumption of the apparatus. Therefore, in order fulfill these conditions, according to the invention, the velocity of the cooling air relative to the power of the compressor is selected to be, or to be larger than, 0.05m/sec W, preferably in a range of 0.05m/sec W - 0.1m/sec W. When a 100W compressor is used, the diameter of the air inlet ports 28 is selected so that the velocity of the cooling air through the air inlet port 28 falls in a range of 5-15m/sec and, preferably, in a range of 5-10m/sec.